STUDIES OF THE TERRESTRIAL ENVIRONMENT IN VICINITY OF ALGOMA STEEL WORKS SAULT STE. MARIE 1976 to 1983

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I Summary

The Ministry of the Environment has periodically sampled vegetation and soil in the vicinity of the Algoma Steel Works in Sault Ste. Marie since 1974. A total of 21 permanent soil and vegetation sample sites were established. The concentrations of iron, arsenic, managanese and fluoride in vegetation (Manitoba maple foliage) decreased with distance from the steel mill. Above normal concentrations of iron, fluoride, and arsenic were found in several vegetation samples collected in 1976 or 1977, but not in 1983. A decrease in concentrations of iron, arsenic, manganese and fluoride was found in the 1983 vegetation collection compared with the previous sample collection. This is believed to be attributed to Ministry abatement measures and decreased production of the steel mill in recent years. No clear relationship existed between vegetation content of sulphur, zinc, calcium and magnesium with distance from the Steel Mill complex.

The results of the soil analyses indicated that arsenic and manganese tend to be higher in close proximity to the steel mill and the waste disposal area. No clear relationship could be demonstrated between distance from the steel mill and soil content of sulphur, iron, fluoride, zinc, calcium and magnesium. Above normal concentration of sulphur, iron

manganese and zinc were found in several soil samples in 1977 and 1983. Arsenic content in soil was only found above normal limits at 2 sites in 1977.

A separate sampling of soils at 3 of the closest permanent locations in the steel mill took place in 1980. These samples were analyzed for polynuclear aromatic hydrocarbons (PAH's). All three locations showed higher PAH's content than the control location. The predominant PAH's by weight were benz (a) anthracene and chrysene. Although no provincial standard or guideline exists for PAH's in soil, the values obtained in this study will be useful as a database from which future trends in PAH's levels can be determined.

II Introduction

The Ministry of the Environment's terrestrial surveillance program in Sault Ste. Marie is primarily being focused on the Algoma Steel Corporation Limited which is Canada's third largest integrated steel producer manufacturing approximately 16% of the steel produced in Canada. Major products from the steelworks in Sault Ste. Marie are seamless tubing for the oil and gas industry, steelplate, nails, wide flange beam, hot and cold rolled sheet and strip. The primary concern of the terrrestrial surveillance program is to assess the effects of emissions eminating from the Algoma Steel Mill on the surrounding vegetation and soil.

Thus, vegetation and soil sampling programs have been undertaken to determine possible contamination trends in the vicinity of the Algoma Steel Mill. The following report summarizes the results of the vegetation and sampling program between 1976 and 1983.

Also included within this report are the results of a 1980 preliminary soil sampling program which was undertaken to determine if polynuclear aromatic hydrocarbons (PAH's) were accumulating in soil in the vicinity of the Algoma Steel Mill. An earlier Ministry of the Environment quality survey showed that airbore concentrations of PAH were higher in proximity to the steel mill (1).

III VEGETATION AND SOIL SAMPLING PROGRAM (1976 - 1983)

a) Program Outline

An initial soil and vegetation sampling program was conducted in the vicinity of the Algoma Steel Works in 1974 and 1975 (1). The samples collected in this program indicated that white birch foliage and soil gathered within 1.5 km of the steel plant contained elevated concentrations of sulphur, fluoride, arsenic, iron and zinc.

In 1976, the sampling program was revised. Fourteen sites were selected at various distances and directions from the steel mill complex. In 1977, the number of sampling locations was increased to 20 and sampling was repeated again in 1983. Results of the 1976-1977 sampling program have been published in a Ministry report (2). The locations are shown in Figure 1. The distance and direction of the sampling sites were measured from the centre of the steel mill complex; however, some sites may actually be closer to a specific contaminant source than indicated due to the physical extent of the complex.

Triplicate samples of Manitoba maple foliage and soil (0-10 cm) were collected at each site. Manitoba maple was substituted for the white birch collected in earlier sampling programs because Manitoba maple was more frequently encountered in the urban environment surrounding the steel mill. Samples were returned to the laboratory for processing.

Vegetation samples were oven-dried, ground in a Wiley mill and placed in glass jars. The soil samples were air-dried, ground using a mortar and pestle to pass through a #45 mesh sieve and bottled. In the Ministry laboratory, they were chemically analysed for sulphur, iron, arsenic, manganese, fluoride, calcium, magnesium and zinc.

b) Derivation and Significance of the Ministry of the Environment's "Upper Limits of Normal" Contaminant Guidelines

The Ministry of the Environment has conducted numerous vegetation and soil sampling programs throughout the Province of Ontario. Based on experience with these programs, as well as on data published in the literature, a set of guidelines has been developed to indicate the concentrations of individual chemical elements which are considered to be above background concentration limits.

The "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (deciduous and current year coniferous trees and shrubs), and grass from areas of Ontario not subject to the influence of point sources of emissions. Samples were collected by Ministry personnel using standard sampling techniques (3).

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant concentration results for samples from "background" locations (i.e., not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are "non-normal", the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless, they will lie within the observed upper range of results for Ontario

samples. Values presented do not necessarily mean that there is toxicity involved, but that there is evidence of contamination above average normal levels. The concentration limits of contaminants in vegetation or soil is considered to be a tool for use by phytotoxicology investigators in interpreting the results of chemical analyses. Certain limitations exist with these established levels, and investigators must judge their use in supplementing other results and observations from field assessment surveys. The following values are used in this report:

Background Concentration Limit

ELEMENT	VEGETATION	SOIL
Arsenic	2 ug/g	20 ug/g
Iron	1000 ug/g	3.5%
Fluoride	35 ug/g	a
Manganese	3000 ug/g	1000 ug/g
Zinc	250 ug/g	500 ug/g
Calcium	3%	3%
Magnesium	0.7%	1.0%
Sulphur	0.4%	0.1%

a - sample size insufficient (<30) to establish guideline

c) Injury to Vegetation

At the time of sample collection in 1977, observations were made on the condition of vegetation in the area of the sample sites. The Balsam poplar foliage at the west end of the Sault Locks (Site 19) was found to exhibit severe injury typical of acute SO_2 injury. Raspberry foliage exhibited trace to light SO_2 injury, while white birch foliage was light to moderately chlorotic. No unusual injury was noted on any other species. At the time of the 1983 collection, no air contaminant injury to vegetation was observed.

ELEMENTAL ANAYSES OF VEGETATION AND SOIL

i) Sulphur

The sulphur content of the vegetation and soil samples is summarized in Table 1. Sulphur concentrations in Manitoba maple in 1976 and 1983 did not show any clear relationship to distance or direction of the steel mill. The 1977 values were higher than those reported for 1976 and 1983 at the majority of corresponding locations. The two highest values of 0.45% and 0.47% sulphur were reported from Sites 19 and 20 respectively in 1977. These were the only samples which exceeded upper limits of normal concentration of 0.4% sulphur in vegetation.

Sulphur values in soil did not show any clear distribution pattern with respect to the steel mill and were variable from year to year at any given site. In both 1977 and 1983, the upper limit of normal concentration of 0.1% sulphur in soil was exceeded at Sites 1 and 9 which are located in close proximity to the steel mill. The other sites which exceeded the background concentration limit were Sites 3, 11, 15 and 20 in 1977 and Sites 7 and 17 in 1983.

ii) Iron

The concentrations of iron in the samples of vegetation and soil are presented in Table 2. Iron values in Manitoba maple in 1976 and 1977 were higher than in 1983. The upper limit of normal concentration of 1000 ug/g was exceeded at Sites 1, 4, 14 and 19 in both 1976 and 1977, but was not exceeded at any location in 1983. The high iron values in Manitoba maple are clearly associated with the Algoma Steel complex as shown in Figures 2 and 3.

The iron values for soil (Table 2) are higher in 1983 than in the preceding years at most sites. The values are quite variable and show no relationship with sampling location with respect to the steel mill. Only the samples from Site 3 in 1977 and 1983 and at Site 11 in 1977 had iron concentrations in excess of the upper limit of normal concentration of 3.5% iron.

iii) Arsenic

Table 3 summarized the arsenic content of Manitoba maple and soil in Sault Ste. Marie. The values for 1983 were substantially reduced in comparison with previous collections of Manitoba maple foliage. The background concentration limit of 2 ug/g was exceeded at Sites 14 and 19 in 1976, at Site 19 in 1977 and at none of the sites in 1983. These two locations are the closest sites to the steel mill in the easterly and southeasterly directions respectively. The distribution patterns for arsenic in the vegetation samples show the higher concentrations of this element to be associated with the steel mill (Figures 4 and 5).

The distribution of arsenic in soil does not show a clear association with the position of the sampling site and the steel mill, since there are apparent localized areas of elevated arsenic concentrations. These localized areas include Sites 3 and 11 where the background concentration limit of 20 ug/g arsenic was exceeded in 1977. The soil appears to have slightly higher arsenic content in close proximity to the steel mill (Figures 6 and 7).

iv) Manganese

The concentrations of manganese in the vegetation and soil samples are shown in Table 4. The concentrations of this element in the foliage was lower in 1983 at almost all sites as compared with 1977 values. The distribution of manganese in the foliage is highest in proximity to the steel mill, as shown in Figures 8 and 9. No background concentration limit have been established for manganese in foliage due to high natural variability.

Manganese concentrations in soil collected at Site 18 exceeded the upper limit of normal concentration of 1000 ug/g in 1976. Since the values were substantially lower at this site in the following year, this value is regarded as anomalously high. At Site 3, the upper limit of normal concentration was exceeded in both 1977 and 1983. The limit was also exceeded at Sites 1, 9, 11, 16, and 17 in 1983. Generally, the soil content of manganese was highest in 1983.

The distribution of manganese in soil is shown in Figures 10 and 11. The manganese concentrations tend to be higher in proximity to the steel mill.

v) Fluoride

The fluoride content of the soil and vegetation samples is summarized in Table 5. The data show that concentrations of fluoride in the Manitoba maple were substantially lower in 1983 as compared with the preceding collections. At five sites (Sites 1, 4, 14, 19 and 20 (1977 only)), the upper limit of normal concentration of 35 ppm fluoride was exceeded in both 1976 and 1977. These sites are all in close proximity to the steel mill, as shown in Figures 12 and 13. Fluoride values for soil did not show any apparent pattern with respect to the steel mill. No background concentration limit has been establish for fluoride in soil because of insufficient sample size.

vi) Zinc

The concentrations of zinc in the samples of Manitoba maple and soil are presented in Table 6. The values for zinc content in the foliage were generally similar throughout the area and were similar for all years.

The zinc content of soil was somewhat variable among sampling locations, but showed no consistent distribution pattern. In 1977, samples collected at Sites 3 and 11 had zinc concentrations above the background concentration limit of 500 ug/g zinc. This was consistent in the 1983 samples only at Site 3.

vii) Calcium and Magnesium

The calcium and magnesium content of the soil and vegetation samples are shown in Tables 7 and 8 respectively. The values vary to some extent among locations and from year to year. The values were all within the normal concentration ranges for the respective samples and elements and did not show any distribution pattern related to the position of the steel mill.

e) SUMMARY OF VEGETATION AND SOIL ANALYSES

Vegetation (Manitoba maple) growing in the vicinity of the Algoma Steel operation was found to contain above normal amounts of iron and fluoride. The concentrations of iron, fluoride, arsenic and manganese in the foliage tended to decrease with distance from the steel mill. The highest concentrations of these elements, including sulphur, were usually measured at the west end of the Sault Locks. A decrease in concentrations of iron, arsenic, manganese and fluoride was observed in the 1983 collection compared with the previous sample collection. This is consistent with the improved air quality attributed to decreased production of the steel mill in recent years.

The concentrations of various elements in soil were generally too variable to demonstrate any effect of the steel mill emissions on the soil; however, there was some indication that arsenic, and possibly manganese, may be accumulating at some sites in close proximity to the steel mill. The soil at Site 3 contained elevated concentrations of sulphur, iron, arsenic, manganese and zinc. Since the other sites between the steel mill and Site 3 have lower values of these elements, it is unlikely that the observed contamination is due to steel mill emissions. Instead, the contamination may be related to proximity of Site 3 to the Algoma Steel waste disposal area located immediately to the south.

IV PRELIMINARY STUDY OF POLYNUCLEAR AROMATIC HYDROCARBONS (PAH's) IN SOIL

Air quality surveys carried out at Sault Ste. Marie from 1975 to 1978 demonstrated that airborne concentrations of polynuclear aromatic hydrocarbons (PAH's) were higher at locations nearer to the steel mill complex as compared with more remote locations (1, 2). As a followup, a preliminary investigation was carried out in 1980 to determine if these compounds were accumulating in the soil. The following is a summary of that investigation.

a) Sample Collection

The three vegetation and soil sampling locations nearest to the steel mill complex (Sites 1, 4 and 19) (Figure 1) were selected for sampling. A site 75 km north of Sault Ste. Marie was chosen as a control or background location. Soil samples were collected at 0-5 and 5-10 cm depths at Sites 1, 14 and 19. In addition, soil was collected at 10-15 cm at Site 1. Only surface soil (0-5 cm) was collected at the control location. The samples were placed in glass jars and forwarded to the laboratory in Toronto for analysis.

b) Sample Preparation

Approximately 20 g of fresh sample was weighed. It was then extracted in an ultrasonic bath, first with acetone (50 ml), then 50% acetone and chloroform (50 ml) and finally chloroform (50 ml). The extracts were combined, filtered and rotary evaporated to 1 ml. The extract was then redissolved in cyclohexane and made up to 50 ml. The solution (2 ml) was chromatographed on deactivated Florisil (2 g contained 15% water), eluting with 50 ml of cyclohexane. The elute was carefully evaporated to dryness. The residue was then dissolved in acetonitrile and water mixture (3:1 V/V) and made up to 2 ml, ready for high-pressure liquid chromatographic analysis.

c) Analytical Methods

Analysis of the prepared samples was carried out using a liquid chromatograph equipped with a reverse phase column. Eluent was a mixture of acetonitrile and water (3:1 V/V). Individual PAH's were detected and quantified using a variable wavelength L.C. fluorometer.

The wavelength of the fluorometer was set at ex=250nm, em>370nm for fluoranthene, pyrene, benz (a) anthracene, chrysene, benz(g.h.i.) perylene, benz (k) fluoranthene, and benz (a) pyrene, and ex=285nm, em>418nm for dibenz (a.h) anthracene, benz (g.h.i) perylene o-phenylene pyrene and anthanthrene. Quantitation was achieved by comparison of chromatographic peaks with those of standards.

Results and Discussion

The following PAH's were identified and quantified:

Fluoranthene	
Pyrene	
Benz (a) anthracene	(BaA)
Chrysene	(Ch)
Benz (k) fluoranthene	(BkF)
Benz (a) pyrene	(BaP)
Dibenz (a.h) anthracene	(DBahA)
Benz (g.h.i) perylene	(BghiP)
O-phenylene pyrene	(OPP)
Anthanthrene	(AA)

The detection limit was 2 ug/kg. Perylene was found in all samples, but because of interference, the amounts could not be quantified.

The chromatograms showed that all eight samples contained similar components. The values for components in each sample are presented in Table 9.

At the present time, the Province of Ontario has no standards or guidelines for PAH's in soil; therefore, it is not possible to comment on the significance of the values obtained in the survey. The values will be useful in a database from which trends in PAH levels can be determined. Although the number of samples examined is small, the following general statements can be made.

1. The values for all PAH's were higher in all samples collected near the steel mill compared with the control location.

2. The predominant PAH's by weight are benz (a) anthracene and chrysene.

3. For most PAH's, the highest concentrations were measured at Site 14, and values at Site 19 were lowest (excluding control sample).

4. At Sites 1 and 19, there is a fairly consistent trend of decreasing concentration of PAH with increasing soil depth. This pattern is not evident at Site 14 where six of the PAH's were higher in the deeper sample.

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TABLE 1

Concentrations(*) of Sulphur (%) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil		
		1976	1977	1983	1976	1977	1983
1	625 m NW	0.27	0.27	0.19	0.10	0.12	0.14
2	1250 m WNW		0.35	0.20		0.05	0.10
3	2375 m W					0.19	0.09
4	1200 m NW	0.22	0.30	0.21	0.03	0.06	0.05
5	1875 m NW	0.22	0.28	0.30	0.02	0.05	0.04
6	1025 m N	0.20	0.31	0.19	0.04	0.06	0.04
7	1700 m N	0.22	0.33	0.22	0.04	0.06	0.06
8	2400 m N	0.17	0.26	0.19	0.06	0.04	0.04
9	1175 m NNE		0.29	0.20		0.14	0.14
10	1750 m NNE		0.29	0.21		0.03	0.04
11	1575 m NE		0.17	0.18		0.19	0.07
12	1975 m NE	0.17	0.27	0.21	0.04	0.06	0.01
13	2325 m NE	0.16	0.32	0.20	0.03	0.04	0.01
14	775 m E	0.18	0.25	0.17	0.09	0.04	0.06
15	1625 m ENE		0.38	0.19		0.12	0.06
16	2250 m ENE	0.20	0.27	0.22	0.09	0.06	0.08
17	1450 m ESE	0.16	0.27	0.20	0.04	0.09	0.10
18	2150 m ESE	0.19	0.27	0.16	0.09	0.09	0.04
19	875 m SSE	0.29	0.45		0.06	0.07	0.05
20	1450 m SE		0.47	0.26		0.19	0.05
Control	8675 m E	0.19		0.21	0.02		0.03

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 2

Concentrations(*) of Iron (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil		
		1976	1977	1983	1976	1977	1983
1	625 m NW	1020	1443	550	17200	12300	24667
2	1250 m WNW		1153	623		5500	26633
3	2375 m W					39800	54000
4	1200 m NW	1913	1620	450	8800	9400	21467
5	1875 m NW	757	863	187	8600	8300	21233
6	1025 m N	847	1150	250	7800	7400	23533
7	1700 m N	727	934	223	6600	8800	24200
8	2400 m N	413	360	107	10800	10100	24367
9	1175 m NNE		1396	460		9900	26967
10	1750 m NNE		963	313		9700	18267
11	1575 m NE		727	443		35700	34567
12	1975 m NE	700	867	407	12300	9100	12667
13	2325 m NE	627	743	380	6900	6400	13000
14	775 m E	1767	1187	767	9600	5100	19667
15	1625 m ENE		823	317		13400	22667
16	2250 m ENE	587	723	313	12700	10100	28667
17	1450 m ESE	957	823	420	8400	12500	21333
18	2150 m ESE	853	603	320	17800	8000	14000
19	875 m SSE	2900	1550		20000	13500	34667
20	1450 m SE		1273	523		16000	20667
Control	8675 m E	250		293	1700		21667

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 3

Concentrations(*) of Arsenic (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil		
		1976	1977	1983	1976	1977	1983
1	625 m NW	1.3	1.3	0.46	16.8	13.9	8.9
2	1250 m WNW		0.8	0.16		1.8	6.8
3	2375 m W					31.7	9.8
4	1200 m NW	1.3	0.9	0.11	3.3	3.6	3.1
5	1875 m NW	0.7	0.5	<0.03	4.3	7.1	7.7
6	1025 m N	0.6	0.5	0.06	4.2	3.3	2.9
7	1700 m N	0.6	0.4	<0.03	2.3	2.8	1.9
8	2400 m N	0.4	0.3	<0.03	2.40	2.3	2.2
9	1175 m NNE		0.9	0.13		7.7	4.1
10	1750 m NNE		0.4	0.06		2.2	1.9
11	1575 m NE		0.4	0.15		30.1	8.5
12	1975 m NE	0.6	0.4	0.08	6.1	3.1	1.0
13	2325 m NE	0.5	0.3	0.20	6.9	3.1	0.9
14	775 m E	2.4	1.6	0.39	9.9	4.6	6.4
15	1625 m ENE		0.5	0.27		8.3	4.0
16	2250 m ENE	0.6	0.3	0.18	6.8	3.5	3.7
17	1450 m ESE	1.0	0.8	0.22	6.7	5.9	5.2
18	2150 m ESE	1.0	0.4	0.16	7.6	3.6	1.4
19	875 m SSE	5.2	3.9		16.4	11.2	9.9
20	1450 m SE		1.2	0.34		12.7	3.8
Control	8675 m E	0.3		0.18	0.9		2.1

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 4

Concentrations(*) of Manganese (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil		
		1976	1977	1983	1976	1977	1983
1	625 m NW	122	157	68	537	509	1030
2	1250 m WNW		103	63		141	666
3	2375 m W					2033	1853
4	1200 m NW	210	158	64	313	355	617
5	1875 m NW	97	66	40	143	190	357
6	1025 m N	110	105	57	303	288	623
7	1700 m N	86	88	51	217	288	574
8	2400 m N	43	46	33	840	205	391
9	1175 m NNE		189	53		646	1390
10	1750 m NNE		83	40		528	603
11	1575 m NE		77	46		117	1313
12	1975 m NE	54	67	42	353	301	217
13	2325 m NE	68	70	50	173	293	297
14	775 m E	260	134	111	307	288	647
15	1625 m ENE		62	46		511	437
16	2250 m ENE	52	37	35	420	327	830
17	1450 m ESE	107	121	81	437	675	1050
18	2150 m ESE	70	46	77	2033	488	437
19	875 m SSE	133	86		520	461	743
20	1450 m SE		132	76		384	497
Control	8675 m E	37		50	28		717

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 5

Concentrations(*) of Fluoride (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil
		1976	1977	1983	1983
1	625 m NW	52	39	6	107
2	1250 m WNW		21	13	87
3	2375 m W			3	123
4	1200 m NW	42	43	5	69
5	1875 m NW	14	8	2	85
6	1025 m N	12	13	4	137
7	1700 m N	11	12	4	150
8	2400 m N	4	4	3	180
9	1175 m NNE		25	5	120
10	1750 m NNE		15	4	140
11	1575 m NE		10	8	140
12	1975 m NE	8	10	6	72
13	2325 m NE	8	9	5	120
14	775 m E	66	60	20	102
15	1625 m ENE		11	5	70
16	2250 m ENE	9	7	4	107
17	1450 m ESE	26	21	7	76
18	2150 m ESE	15	16	5	107
19	875 m SSE	207	128	16	103
20	1450 m SE		46	26	68
Control	8675 m E	3		5	100

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 6

Concentrations(*) of Zinc (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple			Soil		
		1976	1977	1983	1976	1977	1983
1	625 m NW	40	29	23	223	160	215
2	1250 m WNW		23	21		44	165
3	2375 m W					562	446
4	1200 m NW	60	43	28	47	61	73
5	1875 m NW	40	24	44	35	49	63
6	1025 m N	45	35	29	130	80	113
7	1700 m N	37	30	23	63	73	80
8	2400 m N	26	19	18	49	50	67
9	1175 m NNE		41	32		188	230
10	1750 m NNE		32	22		56	62
11	1575 m NE		30	21		540	191
12	1975 m NE	40	32	30	120	102	33
13	2325 m NE	39	36	22	45	56	36
14	775 m E	69	48	36	203	116	287
15	1625 m ENE		42	22		307	79
16	2250 m ENE	33	30	29	137	248	203
17	1450 m ESE	41	38	36	160	310	208
18	2150 m ESE	47	31	30	160	107	68
19	875 m SSE	136	50		163	180	160
20	1450 m SE		31	22		133	81
Control	8675 m E	38		21	14		81

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 7

Concentrations(*) of Calcium (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple	Soil		
		1983	1976	1977	1983
1	625 m NW	13433	2100	2200	8600
2	1250 m WNW	15333		900	6770
3	2375 m W			3400	13933
4	1200 m NW	17000	4200	2300	6610
5	1875 m NW	11767	1000	600	5103
6	1025 m N	21667	2800		8783
7	1700 m N	13333	1900	2100	7550
8	2400 m N	25330	1300	1300	6027
9	1175 m NNE	17667		2400	13233
10	1750 m NNE	10733		2900	5987
11	1575 m NE	15667		1600	14967
12	1975 m NE	15333	2800	1600	3433
13	2325 m NE	14667	1200	4000	3633
14	775 m E	14333	2100	2000	6767
15	1625 m ENE	15667		2600	3533
16	2250 m ENE	15667	2600	1700	7133
17	1450 m ESE	14667	2800	4400	6633
18	2150 m ESE	18000	8800	7200	4067
19	875 m SSE		1500	2400	5167
20	1450 m SE	12100		1700	5100
Control	8675 m E	17667	100		5767

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 8

Concentrations(*) of Magnesium (ug/g) in Manitoba Maple Foliage and Soil (0-10 cm) Collected in the Vicinity of Algoma Steel Corp. at Sault Ste. Marie in 1976, 1977 and 1983

Site	Location	Manitoba Maple	Soil		
		1983	1976	1977	1983
1	625 m NW	2800	3000	1700	5767
2	1250 m WNW	4333		1100	4290
3	2375 m W			3100	5507
4	1200 m NW	4600	4700	1200	3663
5	1875 m NW	2900	2500	1600	5337
6	1025 m N	4667	2900		7777
7	1700 m N	4467	1900	1900	7800
8	2400 m N	6367	5300	2100	8330
9	1175 m NNE	3467		1800	7650
10	1750 m NNE	3133		3000	5727
11	1575 m NE	4567		2100	6570
12	1975 m NE	3467	3500	2100	3833
13	2325 m NE	3600	1600	3800	4033
14	775 m E	3300	1500	900	3267
15	1625 m ENE	3333		2000	4167
16	2250 m ENE	4367	2500	1700	7333
17	1450 m ESE	4433	2200	2800	4433
18	2150 m ESE	4067	6400	3800	3667
19	875 m SSE		2100	2000	4000
20	1450 m SE	3167		1300	4533
Control	8675 m E	4667	200		8200

* Values reported are means of triplicate samples collected in August of year indicated.

TABLE 9

Concentrations (*) of Polynuclear Aromatic Hydrocarbons
in Soil Collected in the Vicinity of
the Algoma Steel Corporation at Sault Ste. Marie
on July 7, 1980

PAH	Sample Depth (cm)	Location			
		1	14	19	Control
Fluoranthene	0-5	625	655	235	9
	5-10	446	1000	75	
	10-15	150			
Pyrene	0-5	550	1762	235	13
	5-10	546	560	125	
	10-15	369			
Benz (a) anthracene	0-5	7250	9523	2720	159
	5-10	4658	9250	960	
	10-15	2087			
Chrysene	0-5	6750	9523	2480	168
	5-10	4600	7750	1200	
	10-15	2330			
Benz (k) fluoranthene	0-5	240	238	68	4
	5-10	134	360	25	
	10-15	57			
Benz (a) pyrene	0-5	482	310	138	5
	5-10	313	650	54	
	10-15	141			
Dibenz (a.h) anthracene	0-5	40	48	4	ND
	5-10	33	88	4	
	10-15	16			
Benz (g.h.i) perylene	0-5	243	429	57	5
	5-10	187	225	44	
	10-15	200			
O-phenylene pyrene	0-5	355	314	35	6
	5-10	204	525	18	
	10-15	83			
Anthanthrene	0-5	148	156	30	ND
	5-10	89	320	13	
	10-15	37			

ND = Not Detectable
* Concentrations reported as ug/kg soil

JJN-03-T

FIGURE 1

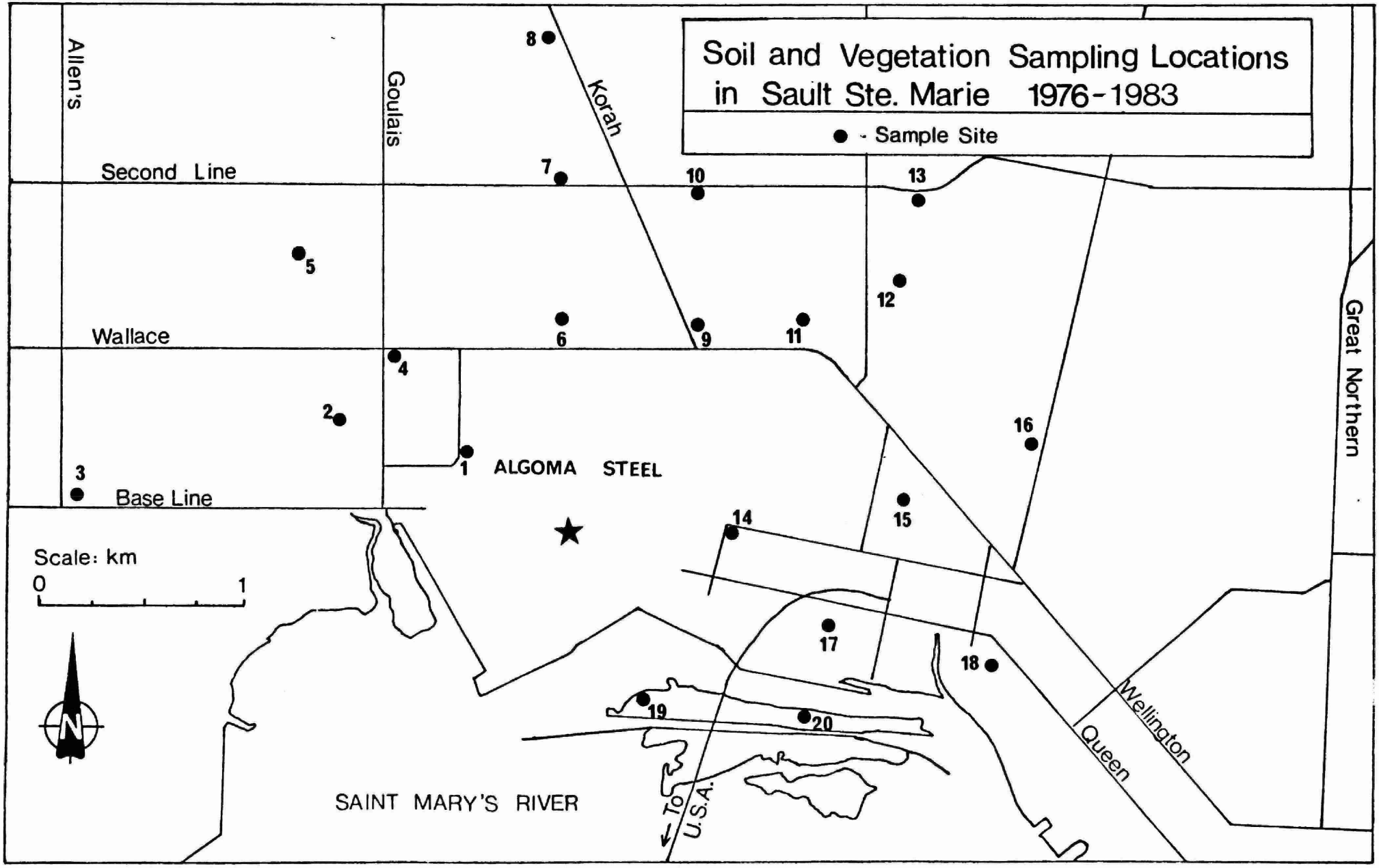

Soil and Vegetation Sampling Locations
in Sault Ste. Marie 1976-1983
● - Sample Site
Allen's
Goulais
Korah
Second Line
Wallace
Base Line
Great Northern
ALGOMA STEEL
SAINT MARY'S RIVER
To U.S.A.
Wellington
Queen
Scale: km
0
1
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

FIGURE 2

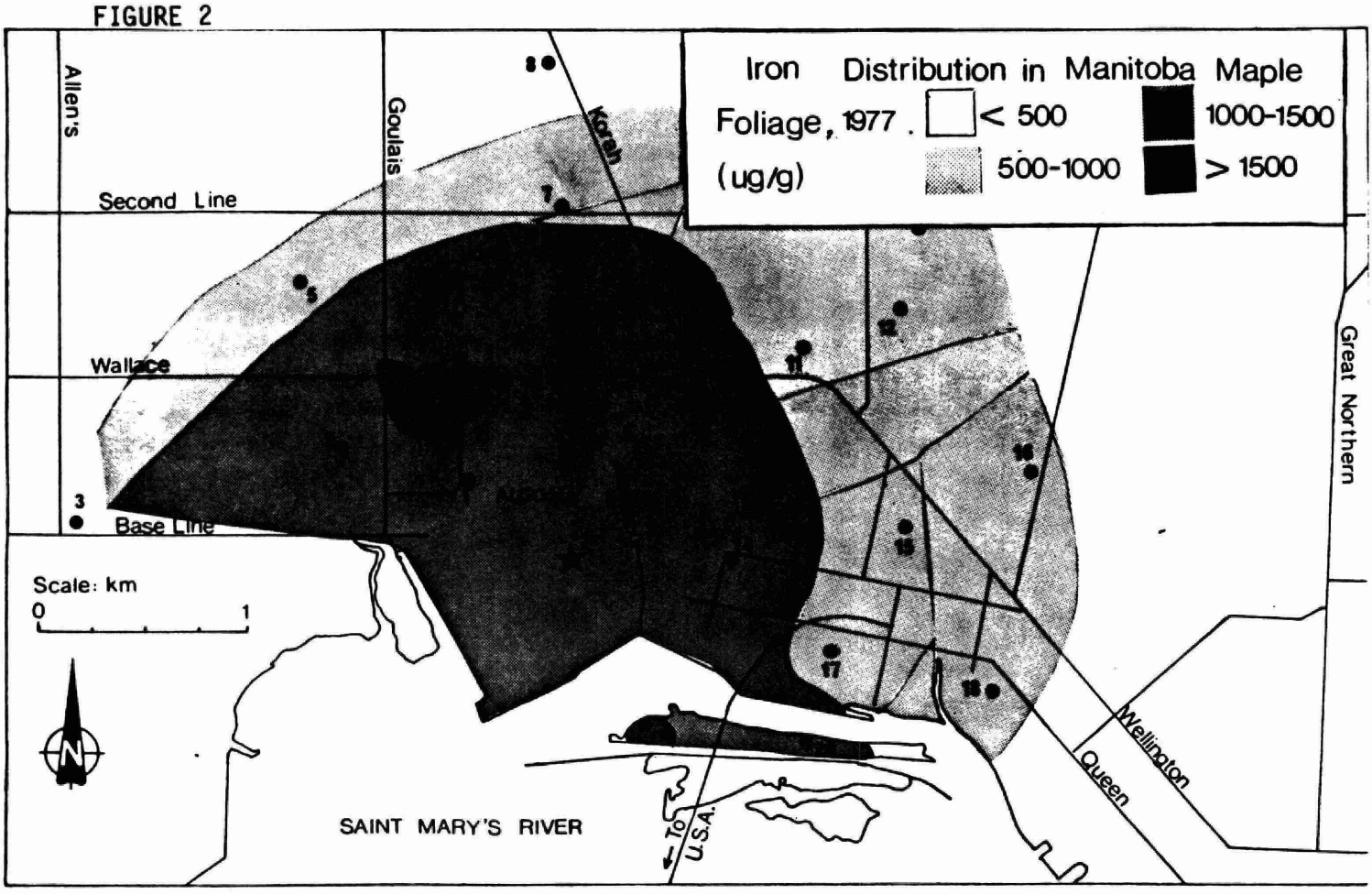


FIGURE 3

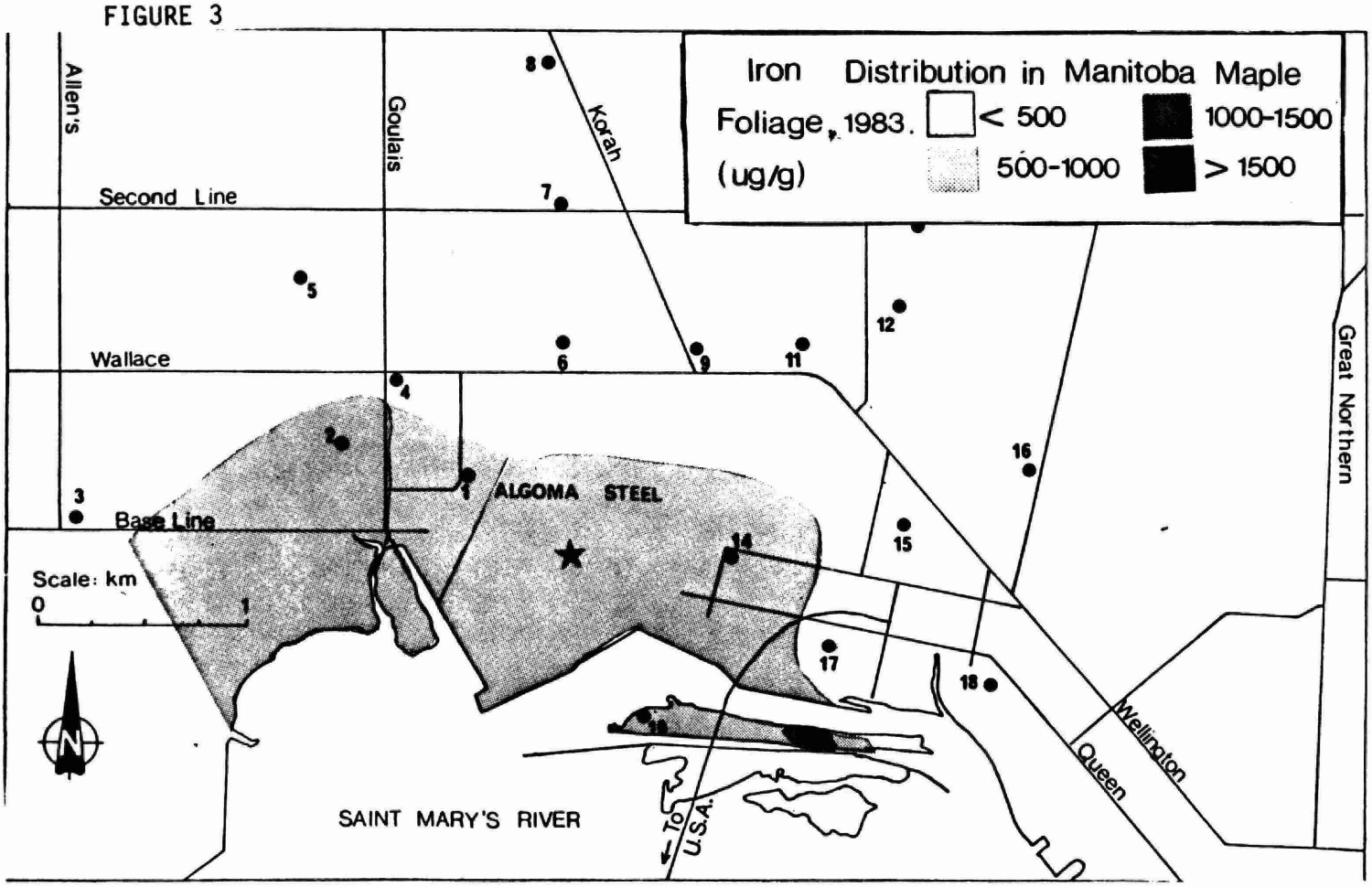


FIGURE 4

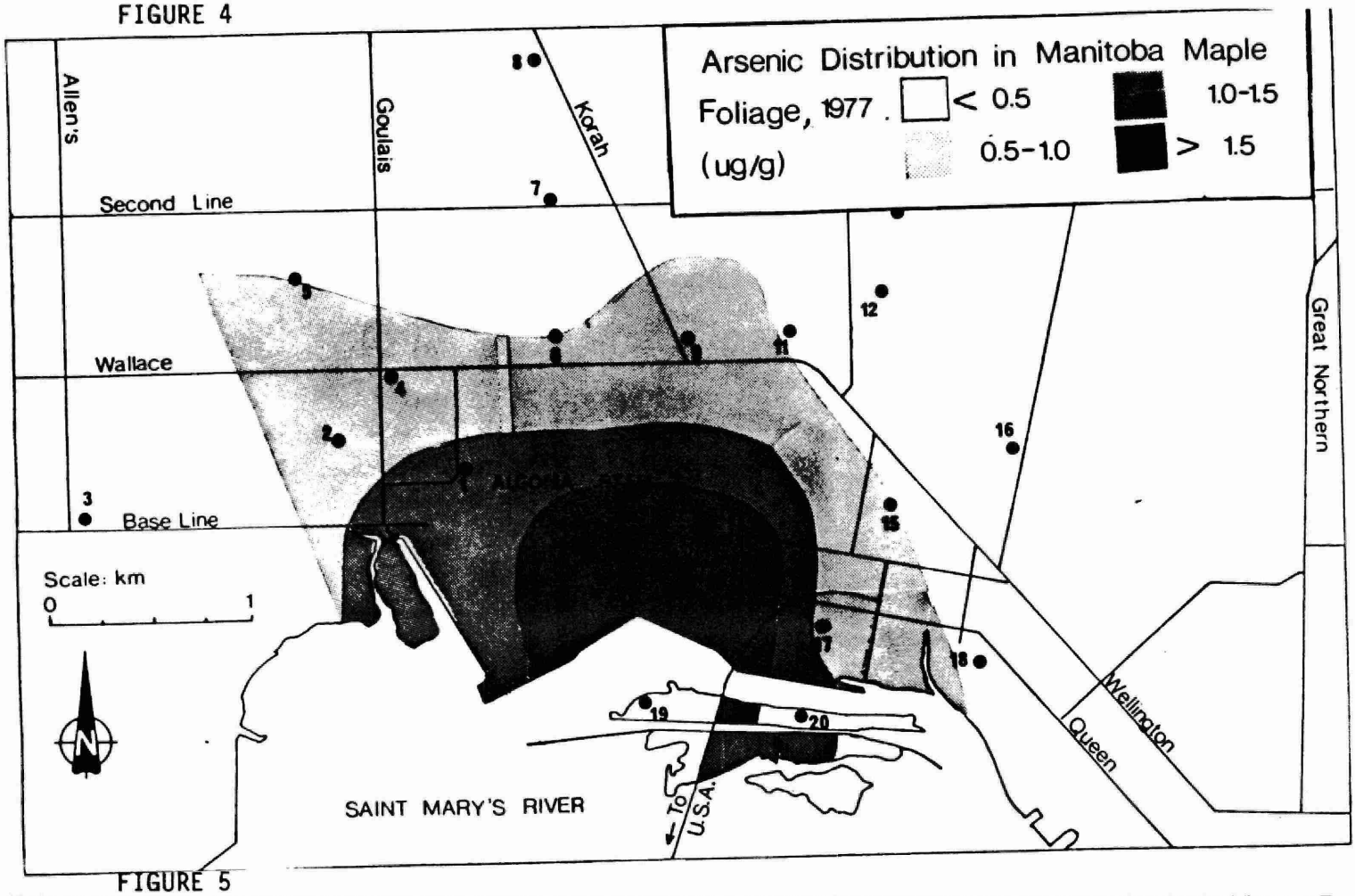


FIGURE 5

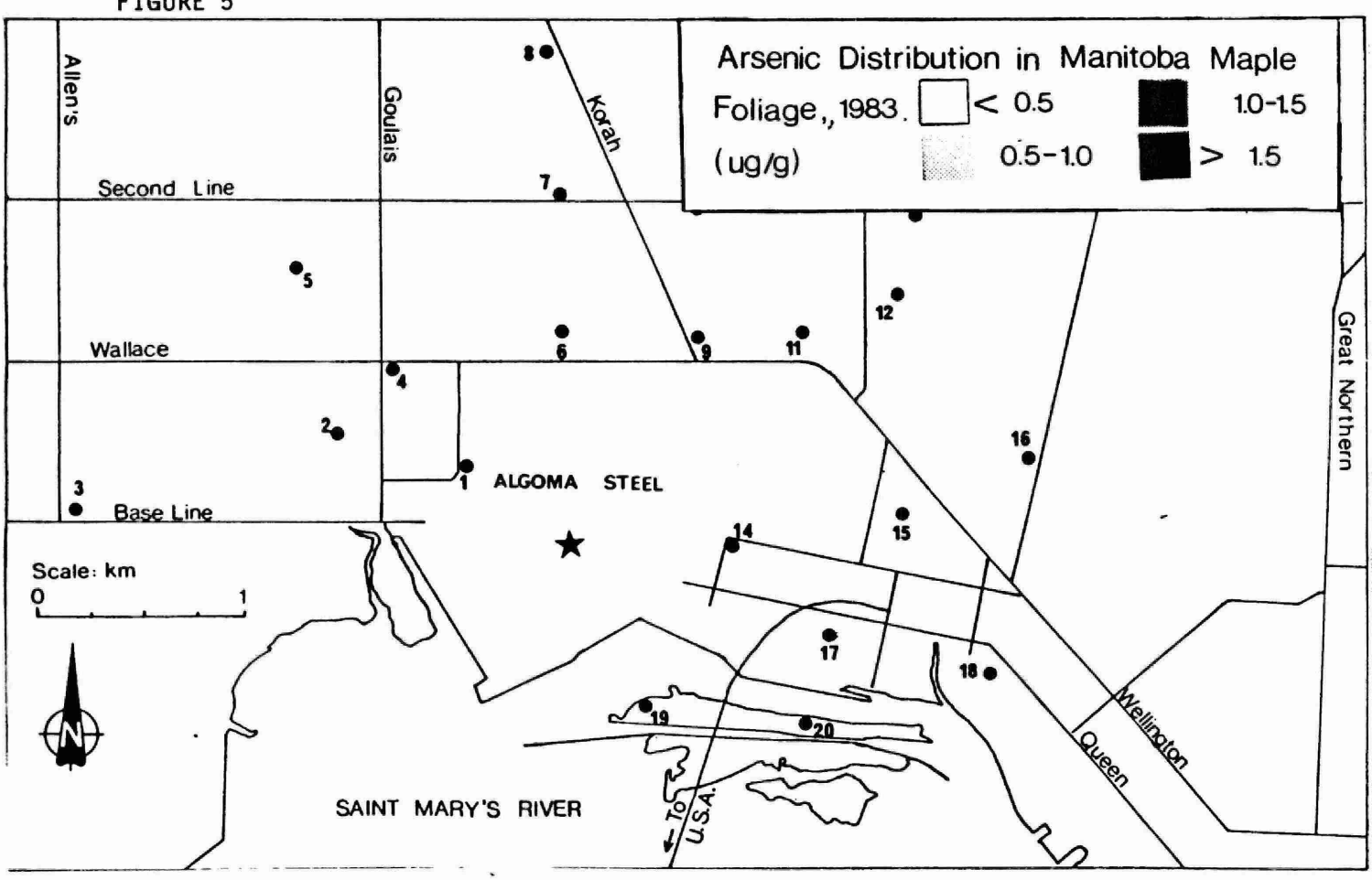
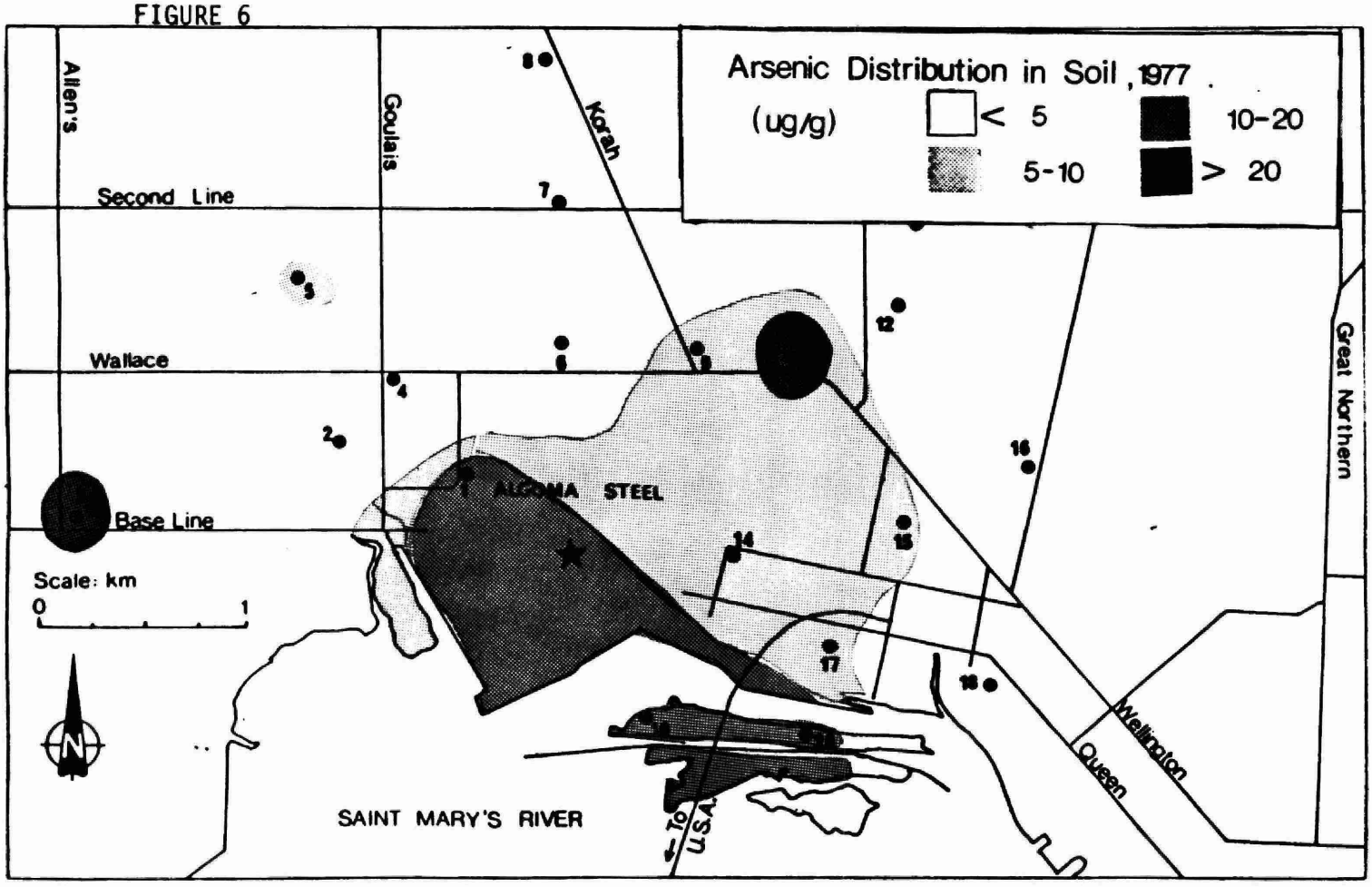


FIGURE 6



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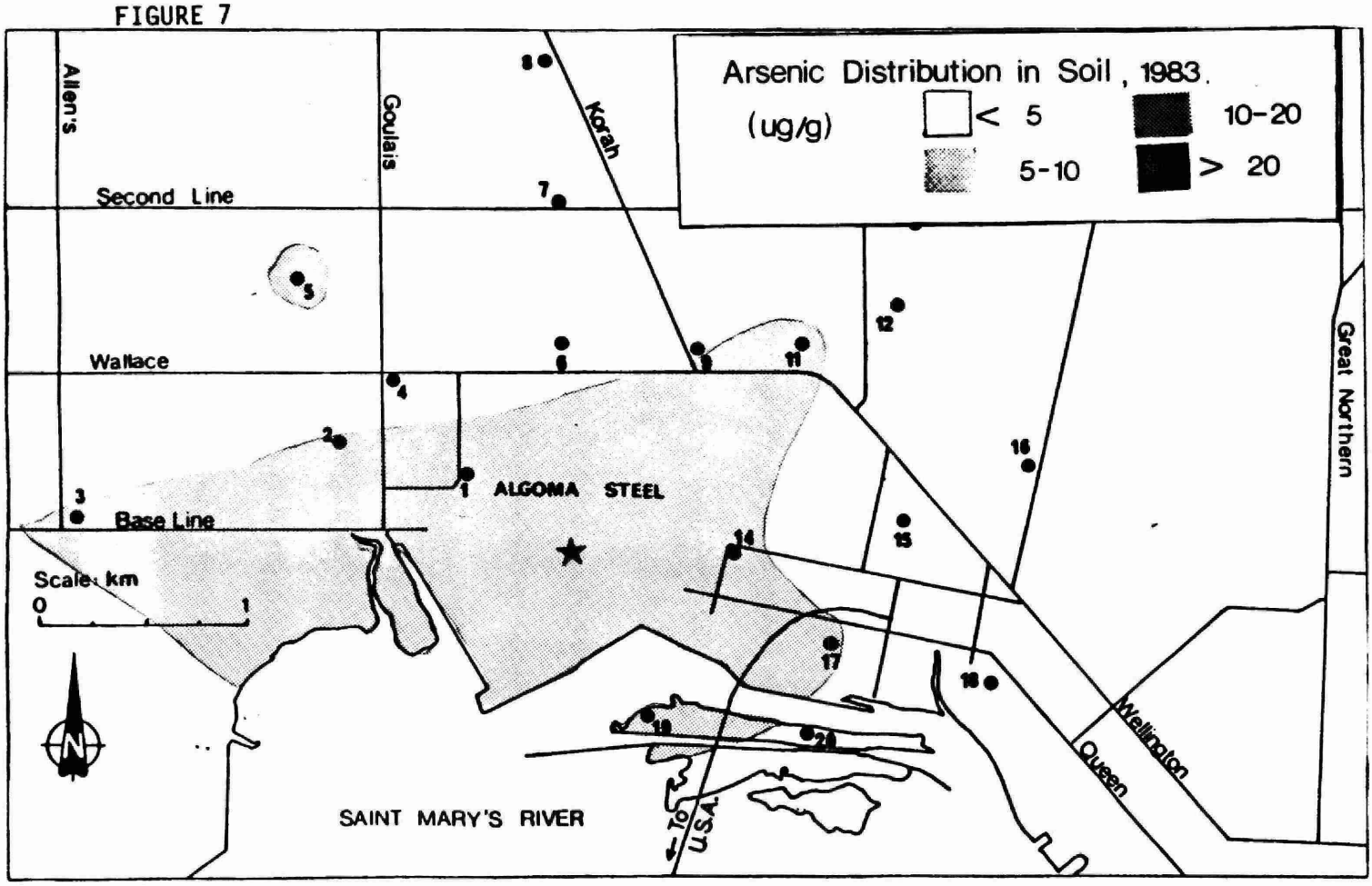


FIGURE 8

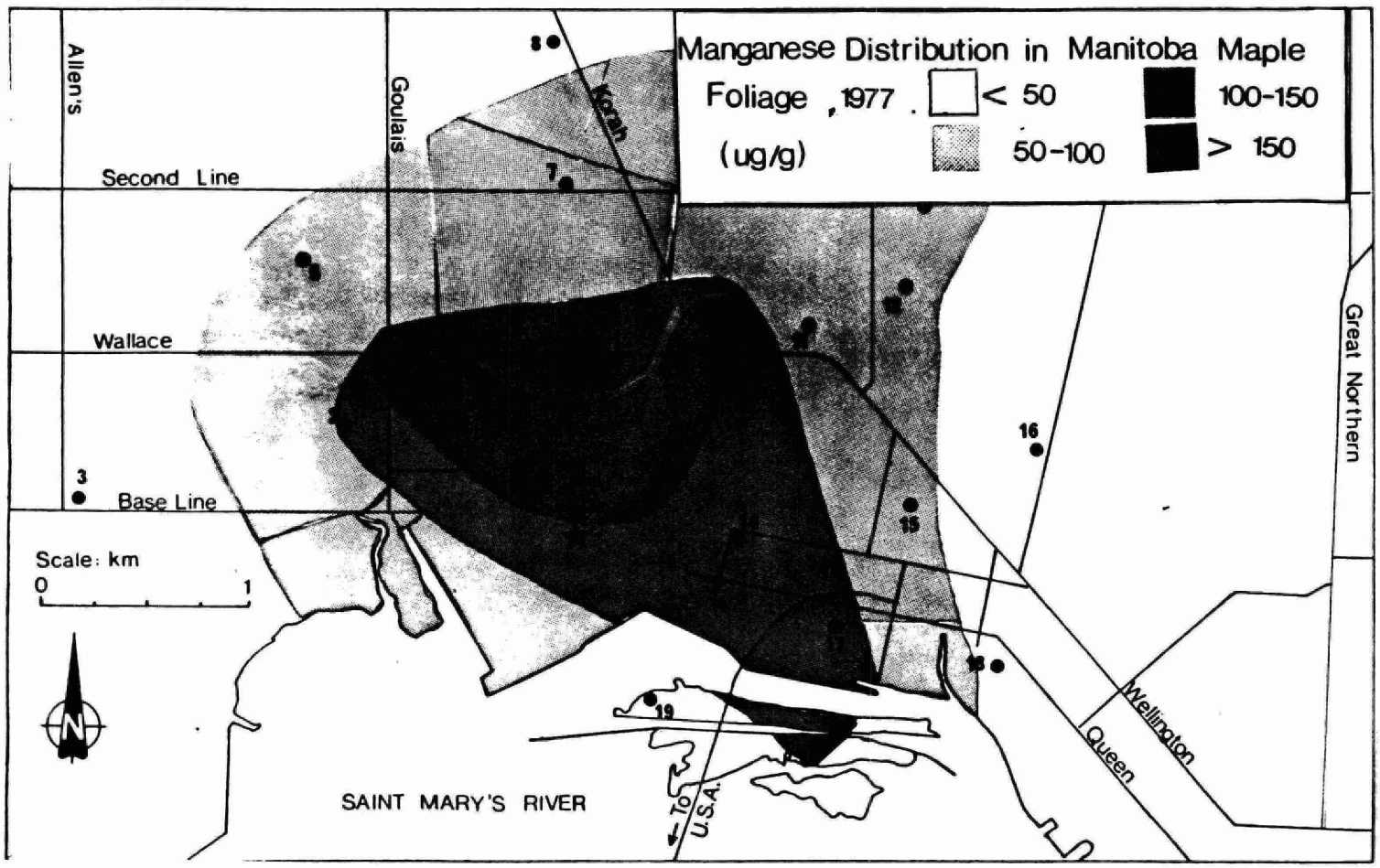


FIGURE 9

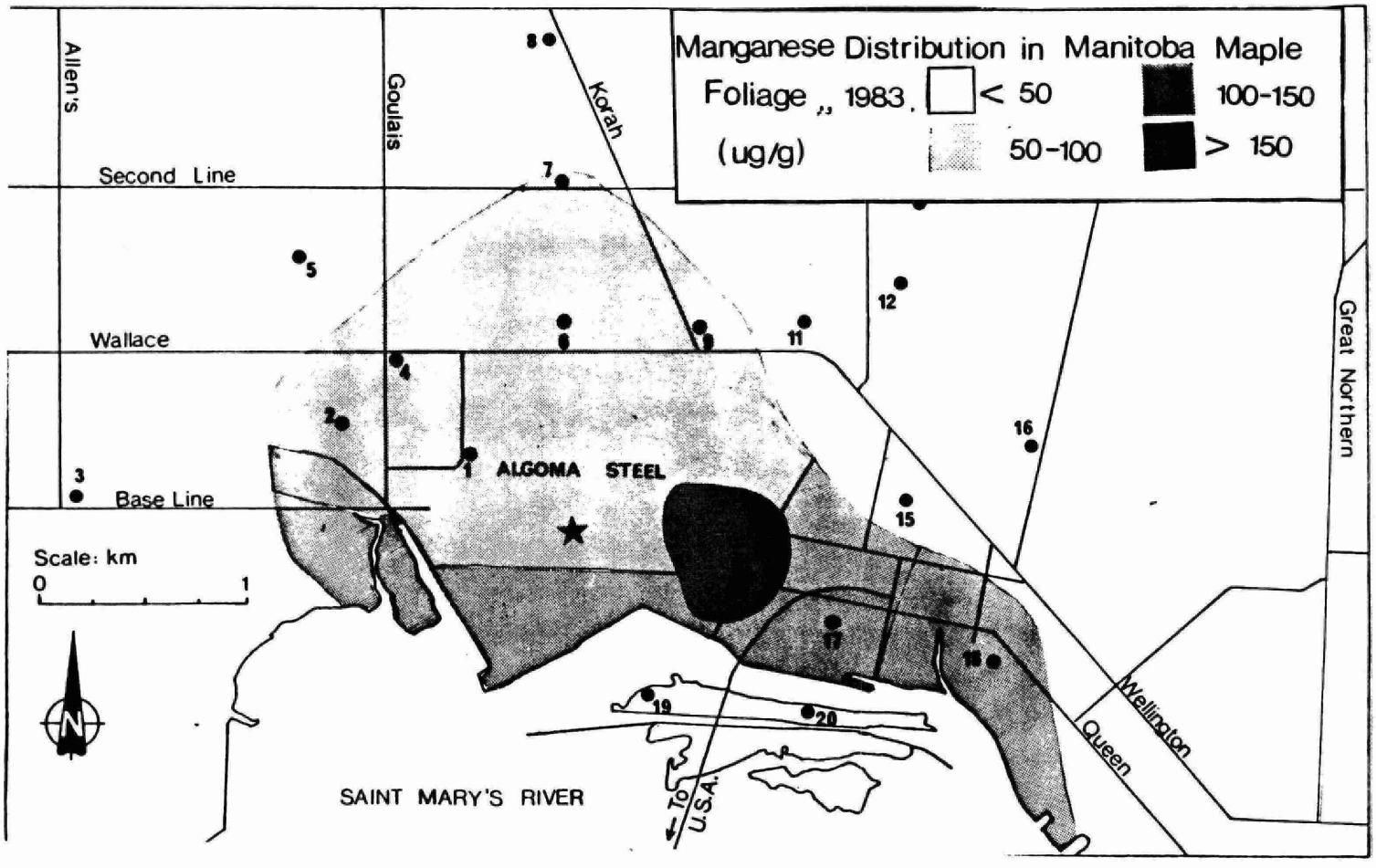


FIGURE 10

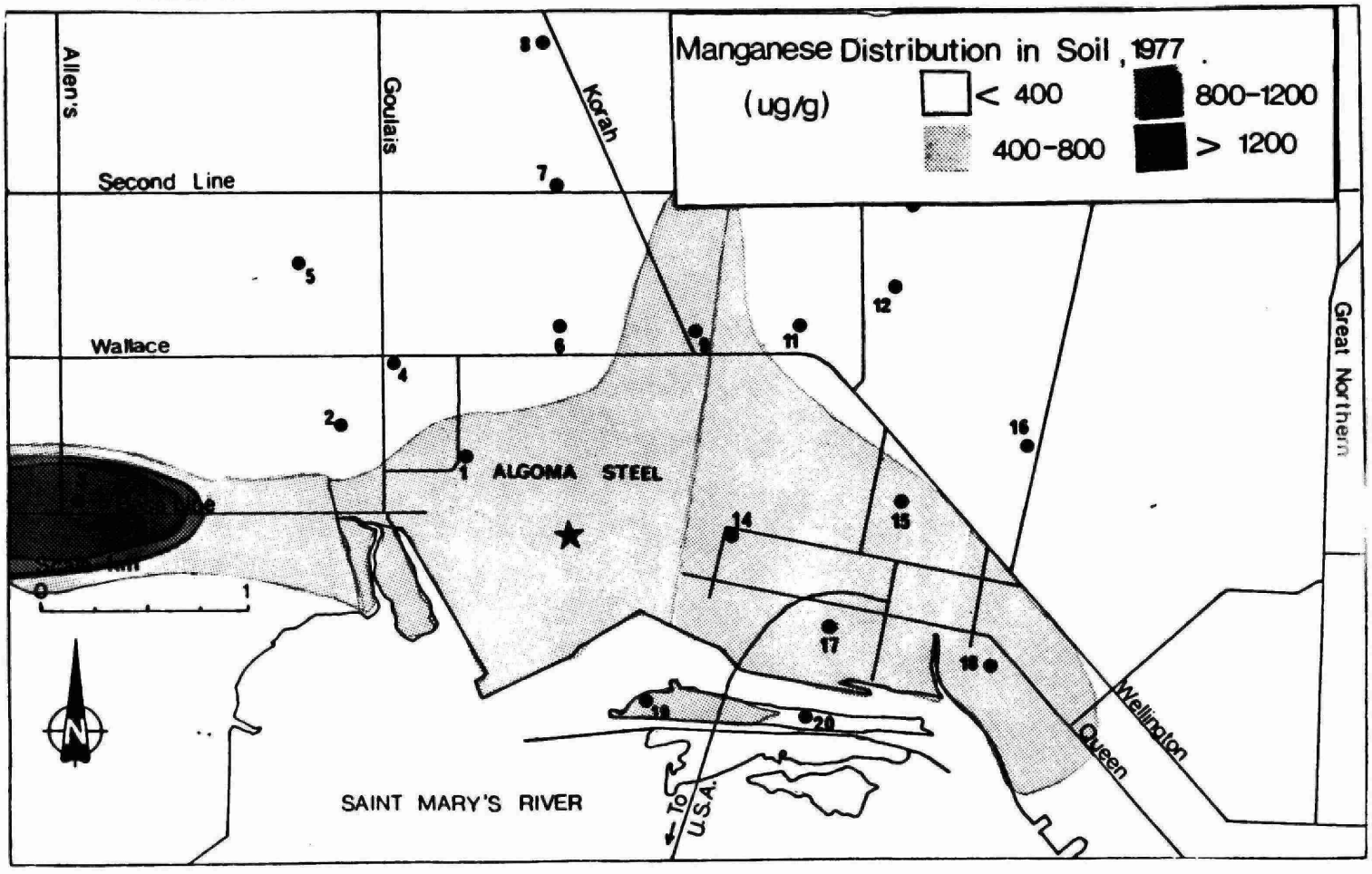
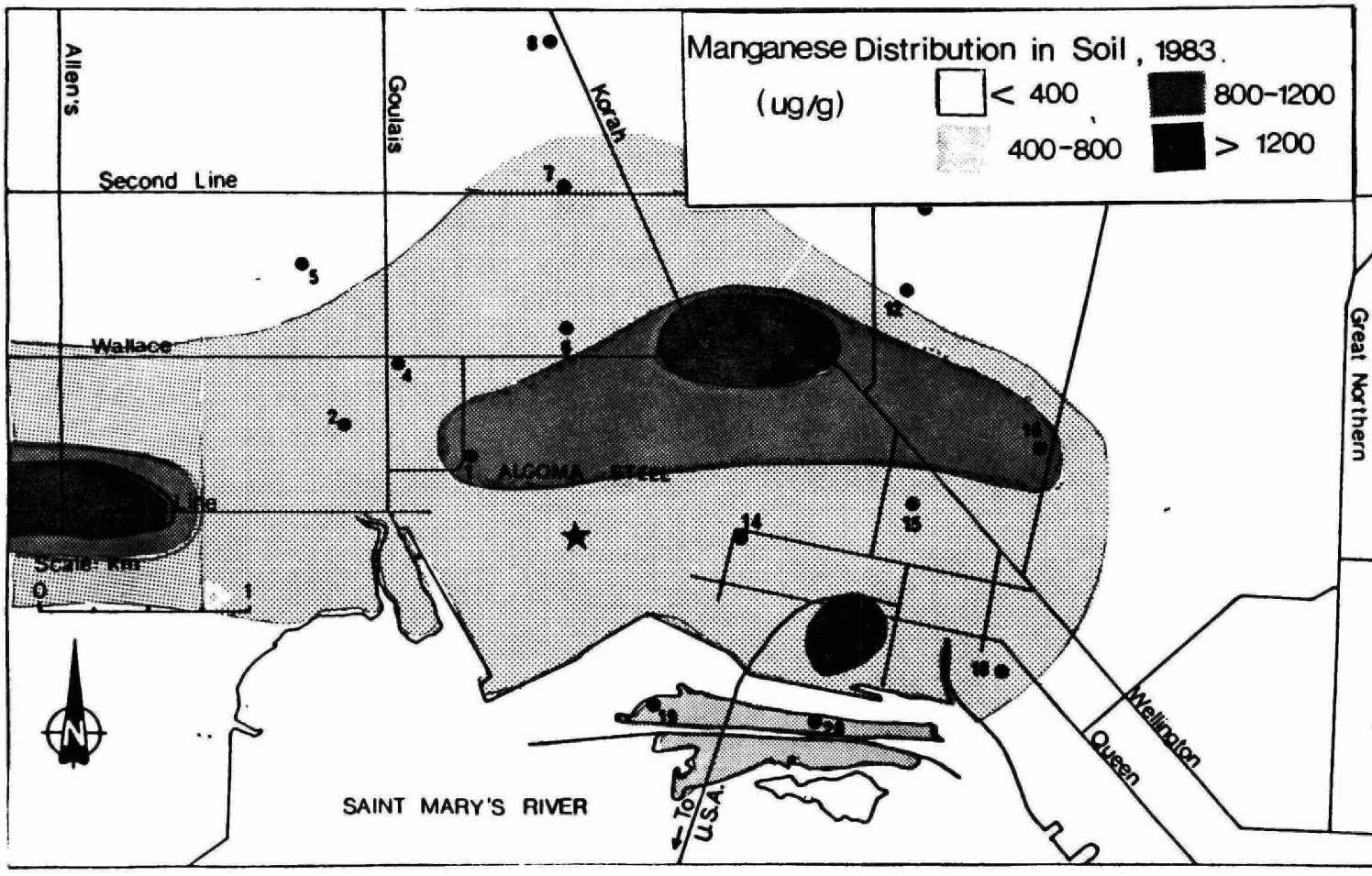


FIGURE 11



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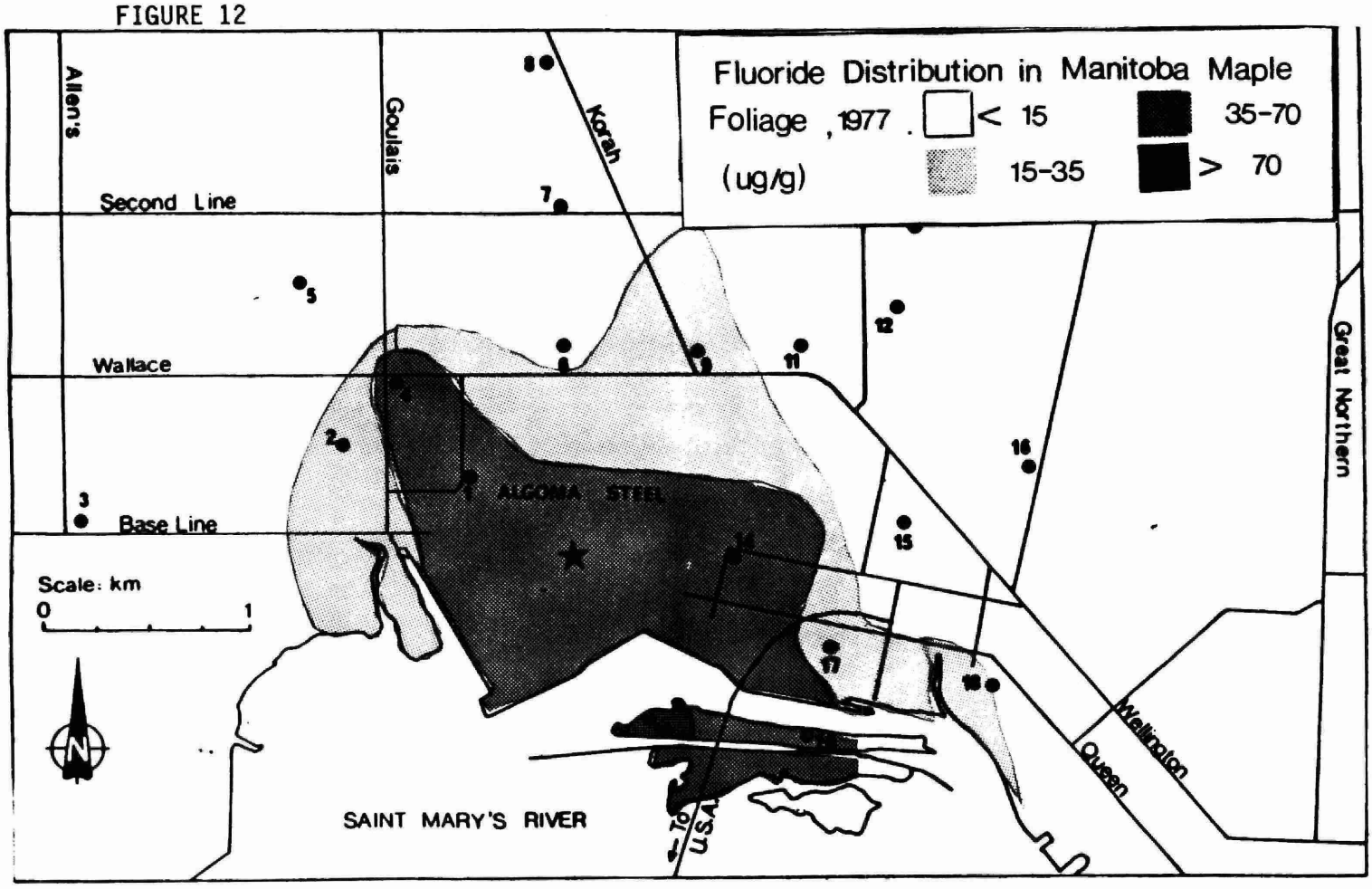
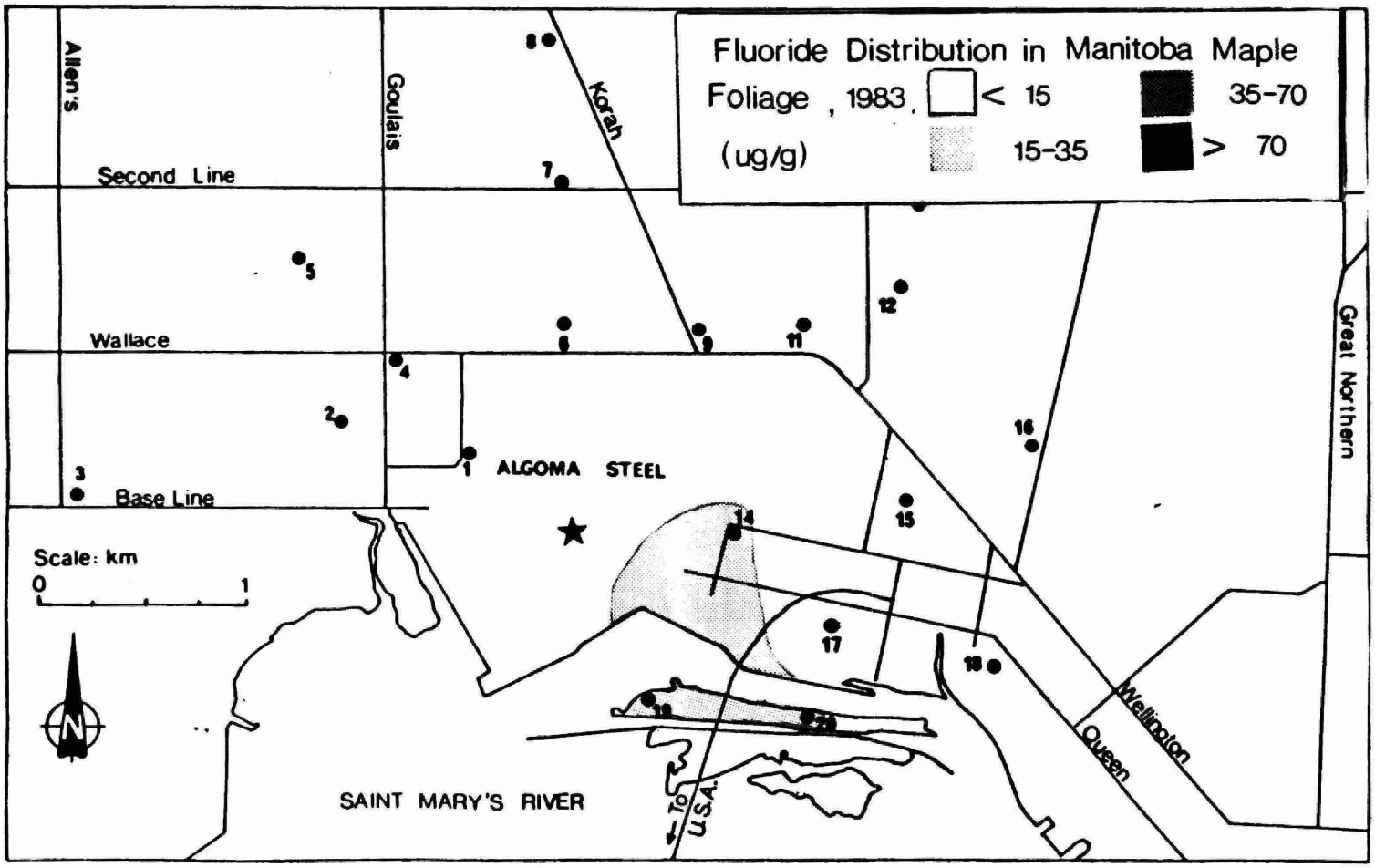
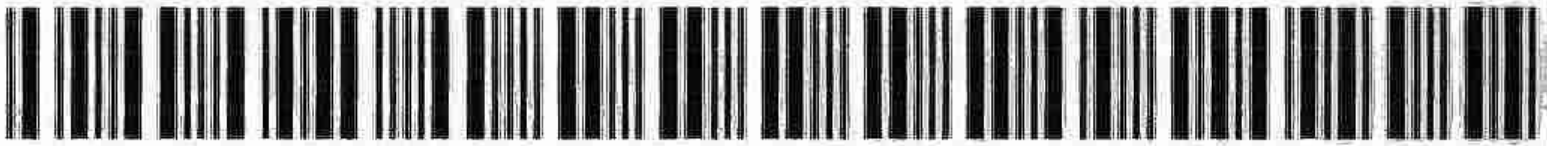


FIGURE 13




9693600000949 5